AFRL-HE-WP-TP-2005-0034

AIR FORCE RESEARCH LABORATORY

Uninhabited Systems and Operator Control

John Reising

Human Effectiveness Directorate
Warfighter Interface Division
Wright-Patterson AFB OH 45433-7022

December 2005

Human Effectiveness Directorate
Warfighter Interface Division
Wright-Patterson AFB OH 45433

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
Dec-2005	Technical Paper	

4. TITLE AND SUBTITLE
Uninhabited Systems and Operator Control

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
John Reising

5d. PROJECT NUMBER
7184

5e. TASK NUMBER
00

5f. WORK UNIT NUMBER
00

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)
Air Force Materiel Command
Air Force Research Laboratory
Human Effectiveness Directorate
Wright-Patterson AFB OH 45433-7022

8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL-HE-WP-TP-2005-0034

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Materiel Command
Air Force Research Laboratory
Human Effectiveness Directorate
Warfighter Interface Division
Wright-Patterson AFB OH 45433-7022

10. SPONSOR/MONITOR'S ACRONYM(S)
AFRL/HEC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
These are briefing charts. Clearance: AFRL/WS-05-2090, 4 Oct 05.

14. ABSTRACT
This was a briefing presented to the UCAV Conference in London UK.

15. SUBJECT TERMS
Uninhabited Systems

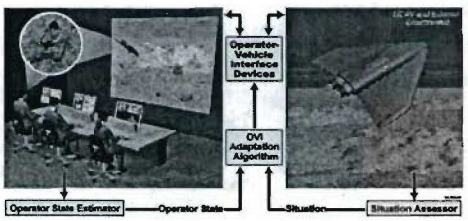
16. SECURITY CLASSIFICATION OF: Unclassified			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			John Reising
UNC	UNC	UNC	SAR	43	19b. TELEPHONE NUMBER *(include area code)* (937) 255-255-8869

AFMC/PA

Air Force Research Laboratory
Human Effectiveness Directorate

Dr. John M. Reising
Technical Adviser
Warfighter Interface Division

Uninhabited Systems and Operator Control



Voice: 937-255-8769
Fax: 937-255-7596
Email:john.reising@wpafb.af.mil
www.hec.afrl.af.mil

AFRL- WS- 05- 0408 18 Feb 2005

Human and Machine Co-operate

Human-electronic Crewmember Conferences

THE HUMAN-ELECTRONIC CREW: CAN THEY WORK TOGETHER ?

Conference Room at Stadttheater Ingolstadt

Ingolstadt, FRG, 19 - 22 Sept 1988

THE HUMAN-ELECTRONIC CREW: CAN WE TRUST THE TEAM?

Proceedings of the 3rd International Workshop on Human-Computer Teamwork

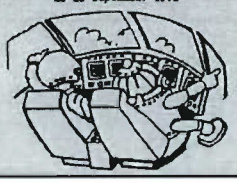
Cambridge, United Kingdom, 27-30 September 1994

THE HUMAN – ELECTRONIC CREW: IS THE TEAM MATURING?

The 2nd Joint GAF/RAF/USAF Workshop on Human – Electronic Crew Teamwork

Stadttheater Conference Room, Ingolstadt, FRG

25-28 September 1990



THE HUMAN-ELECTRONIC CREW: THE RIGHT STUFF?

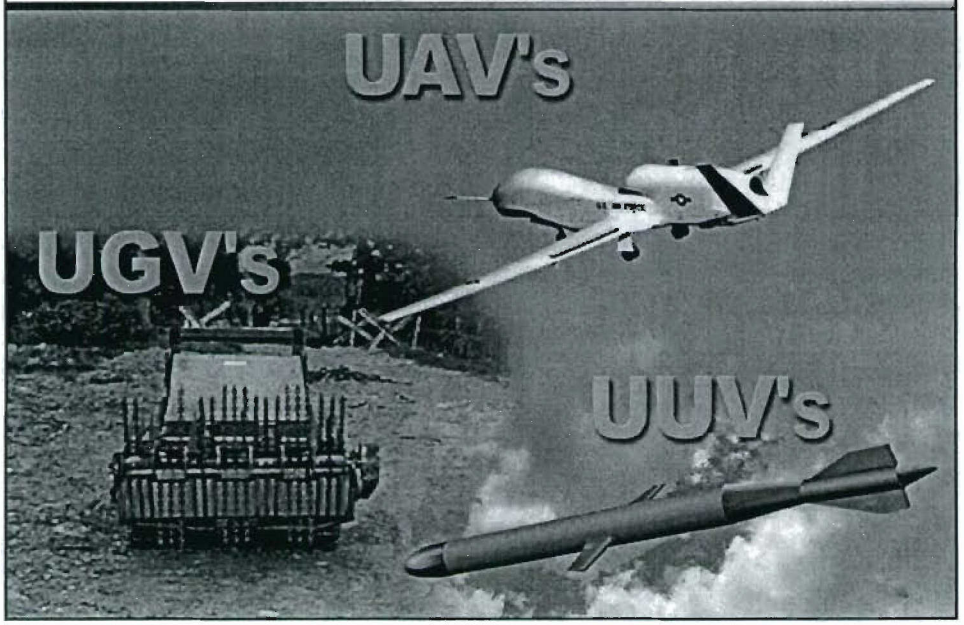
Proceedings of the 4th Joint GAF/RAF/USAF Workshop on Human-Computer Teamwork

Hotel zur Post, Kreuth, Nr Tegernsee, Germany

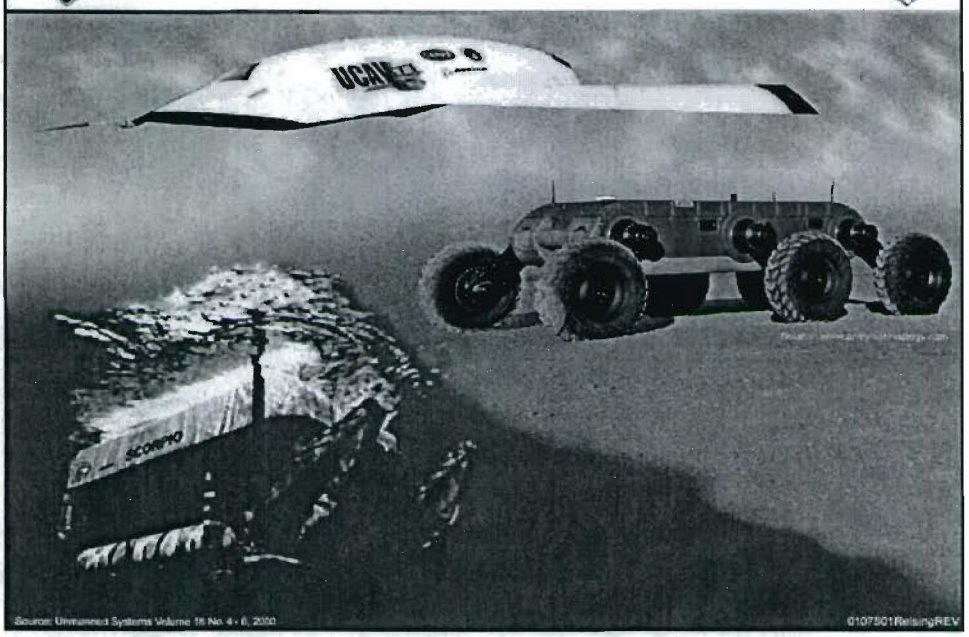
23 - 26 September, 1997

THREE PHASES OF SUPPORT

Application Areas for Unmanned Vehicles



Air, Ground, and Undersea Examples



Source: Unmanned Systems Volume 18 No. 4 • 6, 2000

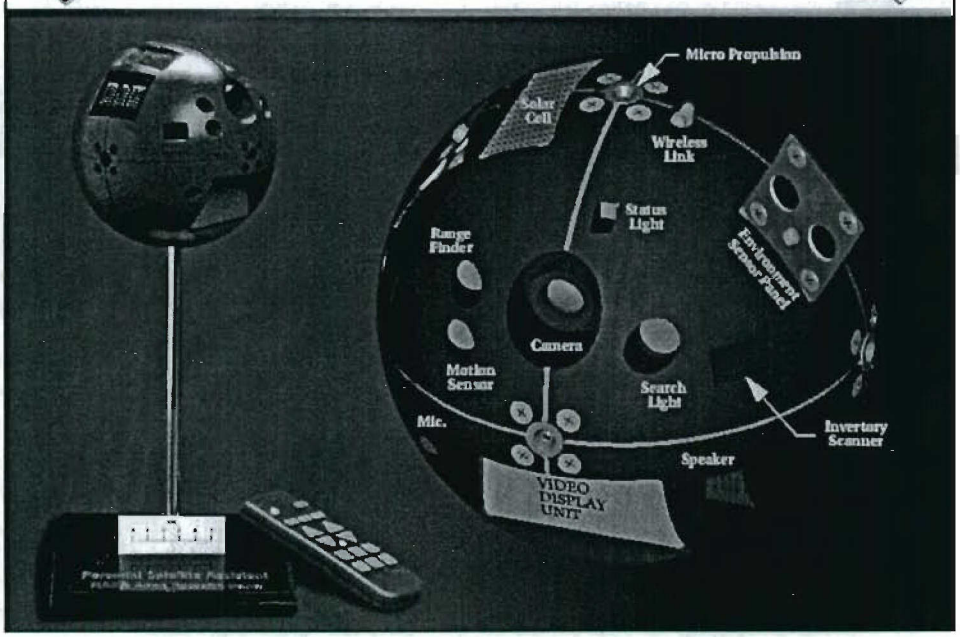
0107501ReisingREV

Supervisory Control

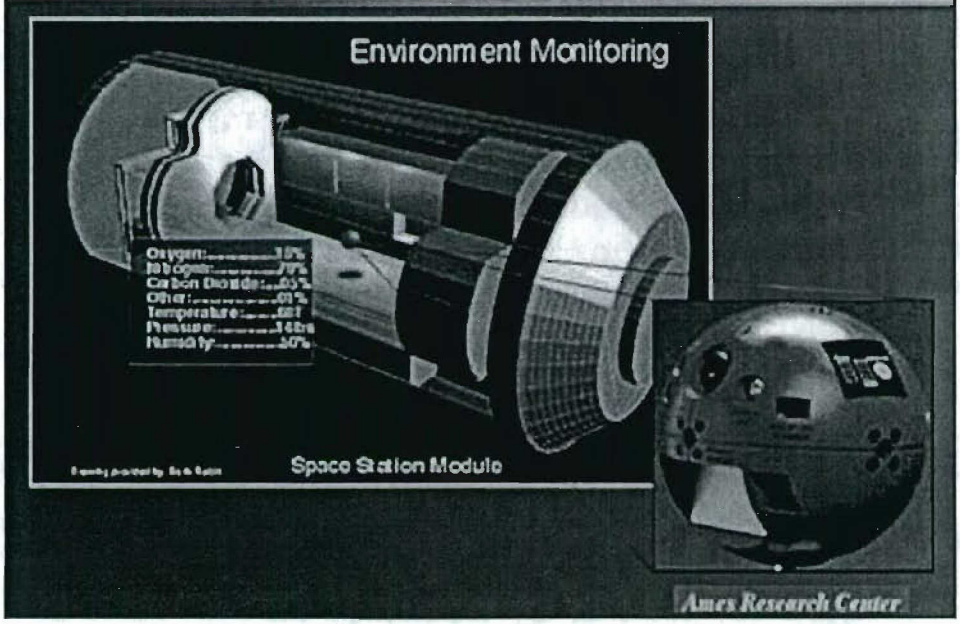
" Specifically, supervisory control means that human **operators plan and teach** tasks to computers, and the **computers then implement** the tasks automatically through their own sensory inputs, memory and control actions"

Sheridan, p.450, in Parasuman & Mouloua, 1996.

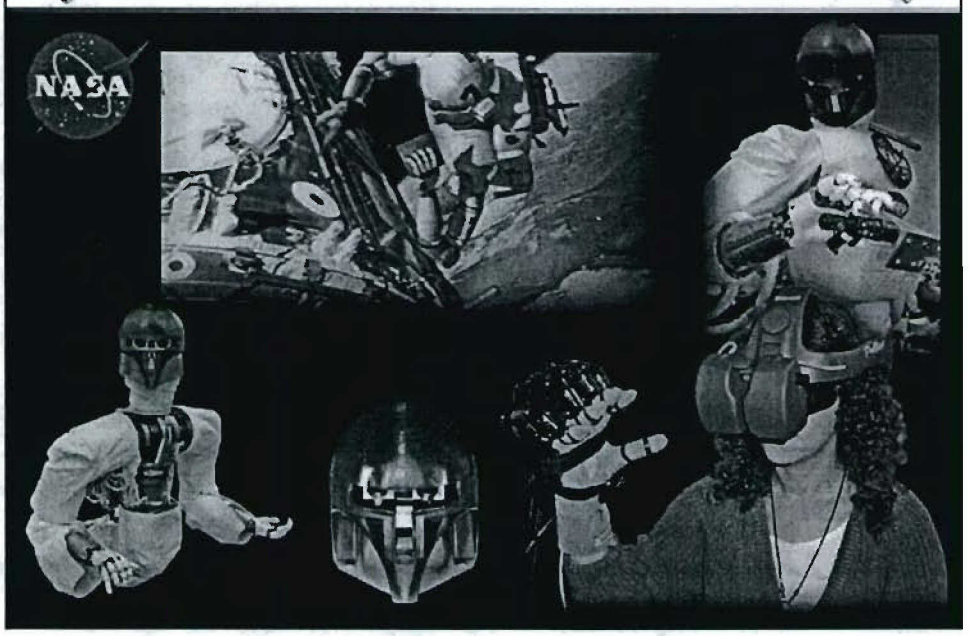
Personal Satellite Assistant



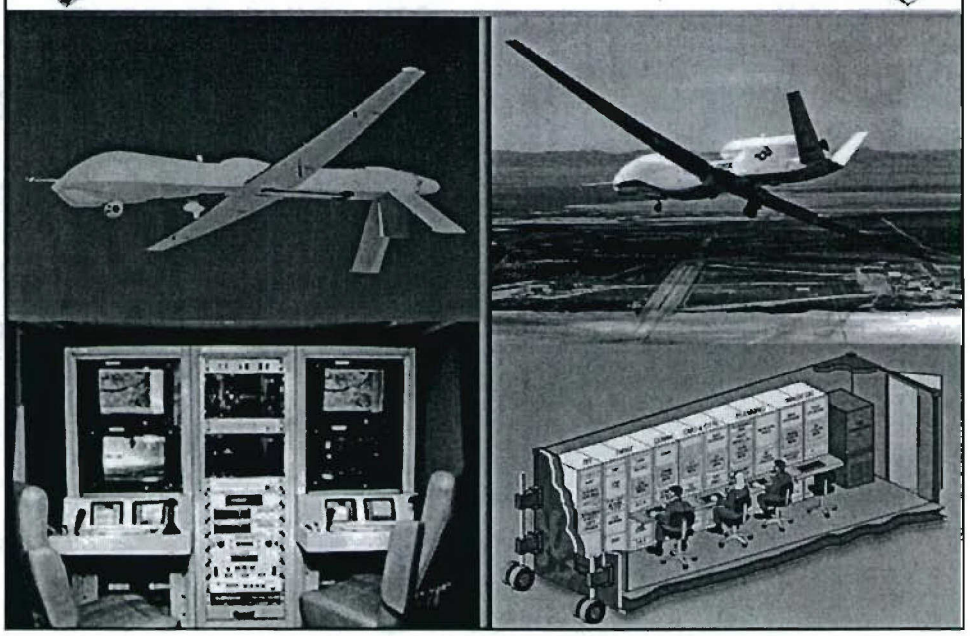
Personal Satellite Assistant Application



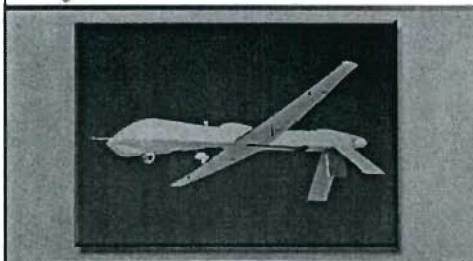
Robonaut



Current USAF UAVs



Predator and Ground Control Stations



Predator Ground Control Station

http://www.ga.com/asi/photolib/photolib.html

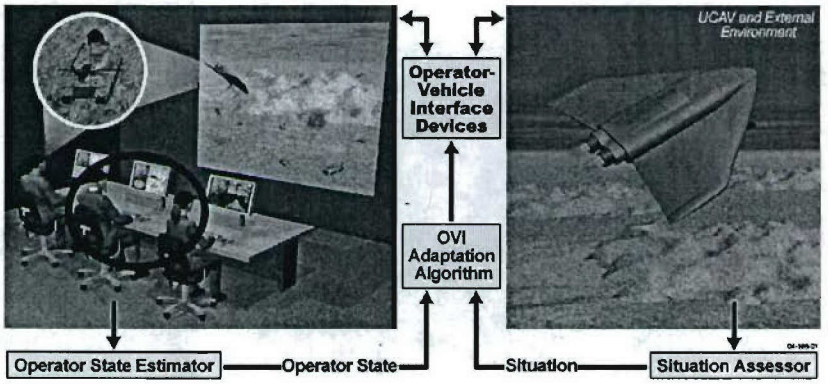
Tactical Control Station

http://home.navair.navy.mil/tcs/images/images.html

Dragon Eye

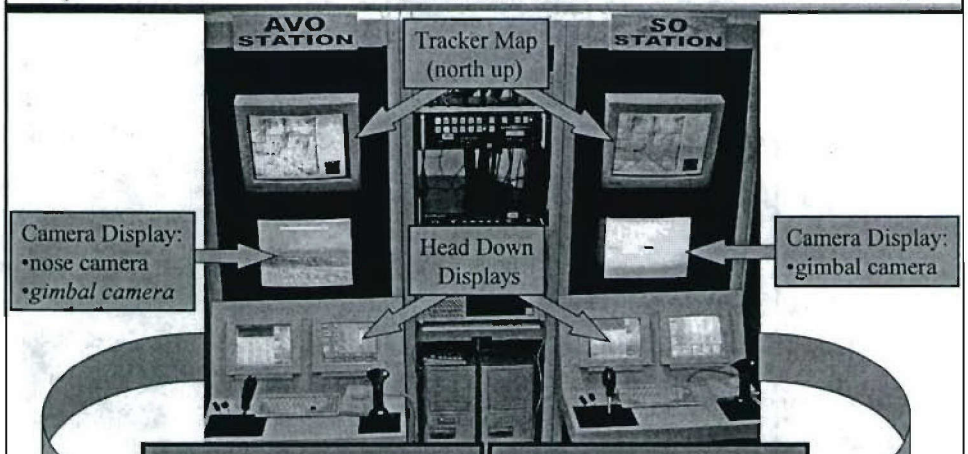
http://www.beyond2000.com/news/May_01/story_1134.html

Operator-Vehicle System Diagram



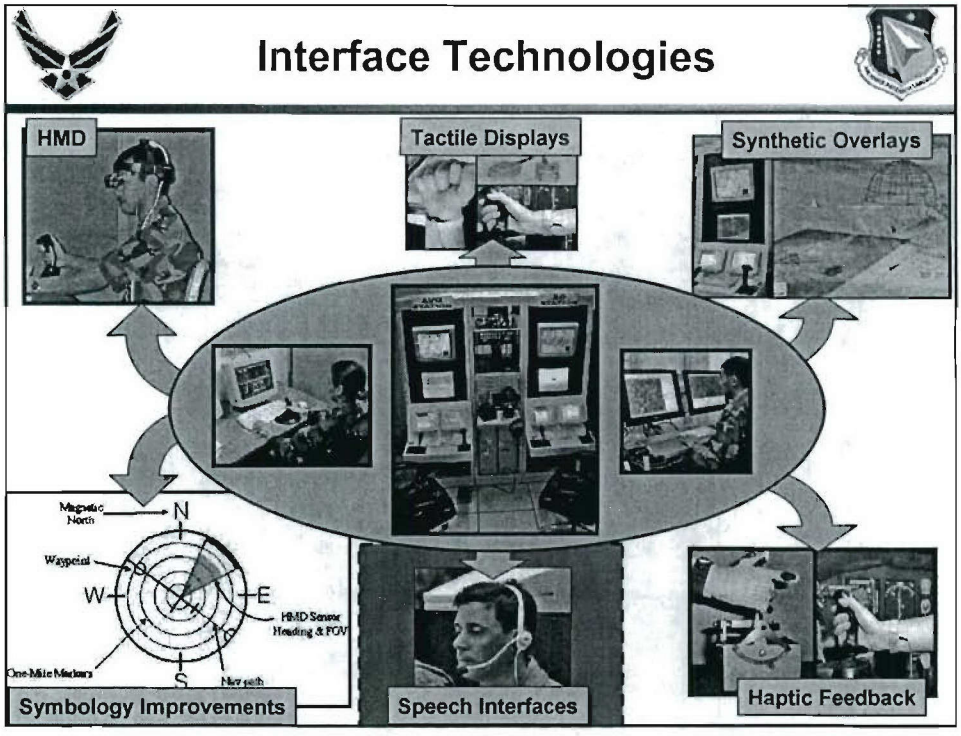
13

UAV Ground Control Station Simulator



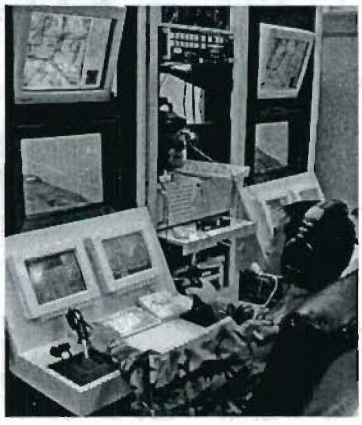
14

Interface Technologies



Rationale for Speech Input in UAV Control Stations

- Natural and intuitive interface
- Mature technology
  - Real-time
  - Accurate
  - Speaker-independent
- Reduces resource competition
- Hands-free control
- Heads-up control
- "Voice macros" can replace complex series of manual inputs



Speech input improved performance in manned aircrew applications

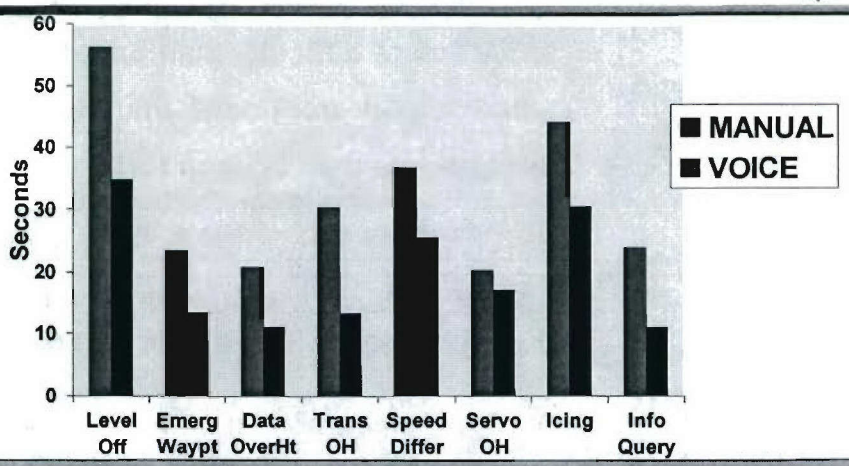
Speech Input Implementation

- Speech Recognizer:
  - Nuance v8.0
  - continuous, speaker-independent
- Vocabulary:
  - 70 commands
  - Total vocabulary: 160
- Push-to-Talk button (on joystick)
- Sennheiser 280-13 Pro headset/mic
- Visual feedback of commands on HUD
- Auditory environment: benign

NUANCE
The New Voice of Business

17

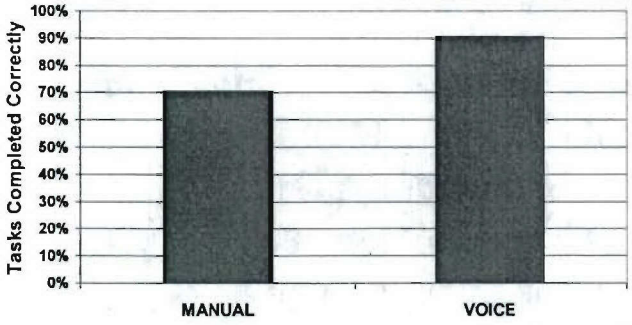
Results – Speech Better:
Mean Task Completion Time



- Speech input significantly faster for all task types
- Average time savings range: 3.14 to 21. 43 seconds
- Data entry time reduced by approx 40% with Speech Input

Results – Speech Better: Mean Task Completion Accuracy

Speech Input more Accurate than Manual

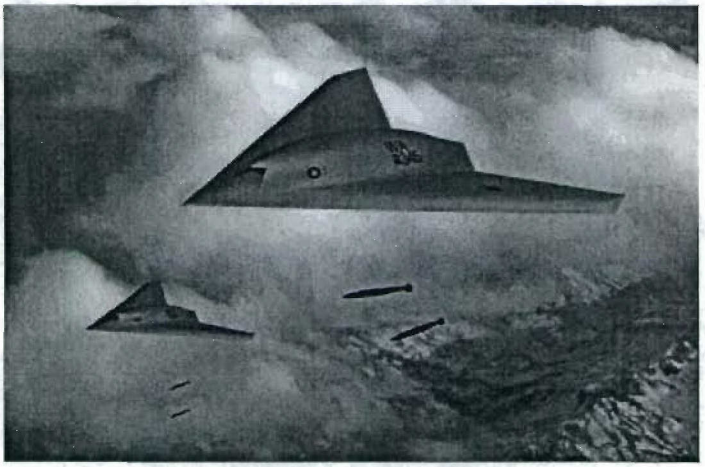


- More tasks completed *correctly* with Speech: *Voice macros are a factor*
- Time outs less with Speech: Operators more frequently completed trials within the experimenter-specified time limit with Speech Input.

Results – Speech Better Subjective Data

OPERATOR RATINGS	• Manual "more difficult" than Speech • Manual "higher workload" than Speech • Manual worse than Speech for: •Interference with flight/navigation task •Speed and accuracy of data entry
OPERATOR COMMENTS	MANUAL: "Menu…unintuitive." "Info buried too deep." "Have to be heads down." VOICE: "Voice was just so much easier." "You can stay heads-up." "Greatly reduced workload."

UCAV

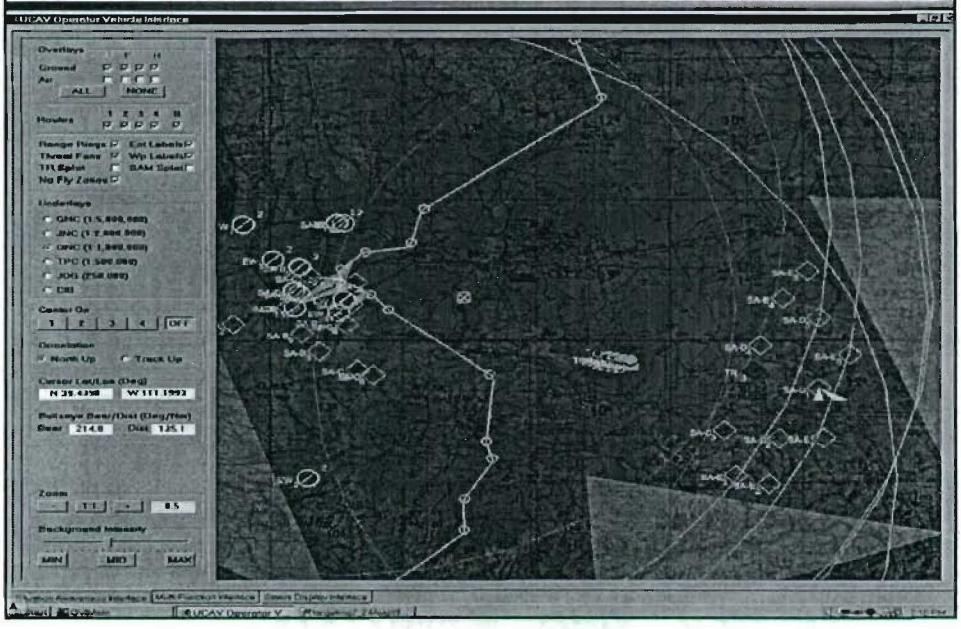


Col Michael Leggett, UCAV Conference, London 2003

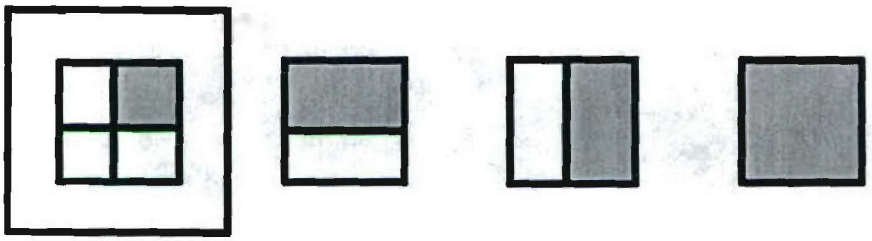
Operator's Console Example

Operator Vehicle Interface Workstations

Situational Awareness Display Format

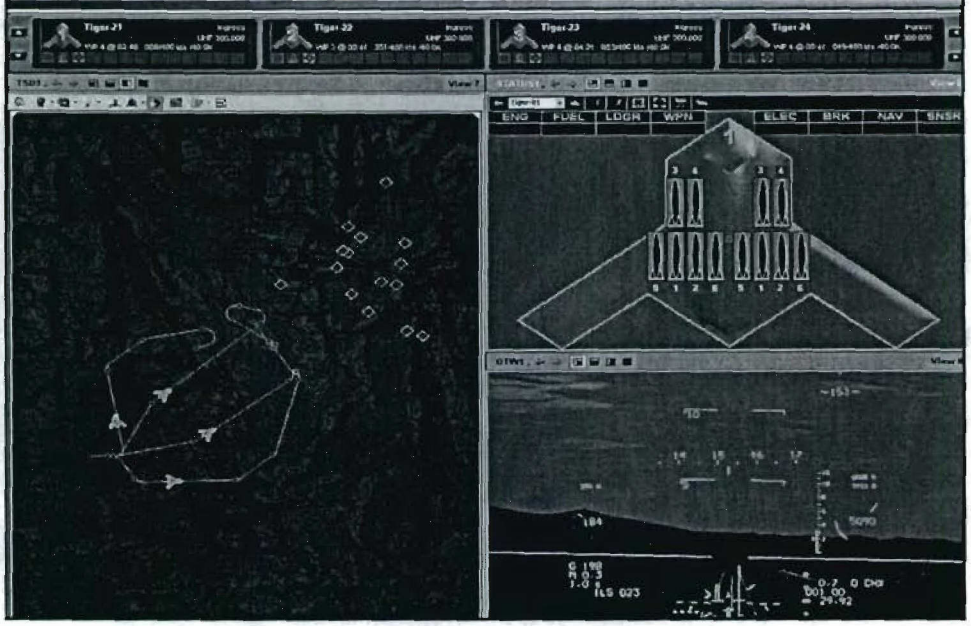


Quadrant Selection Icons

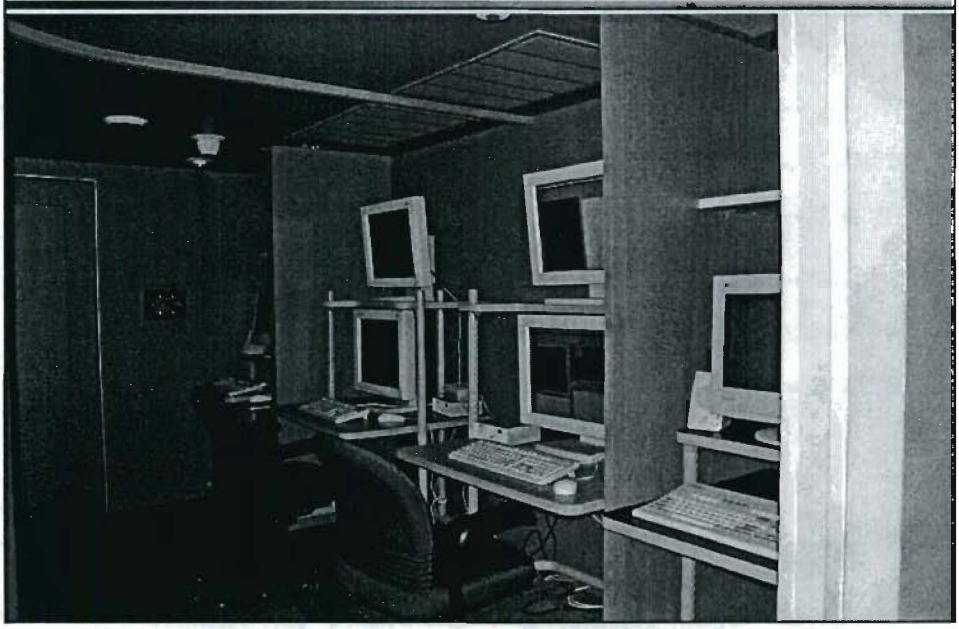


25

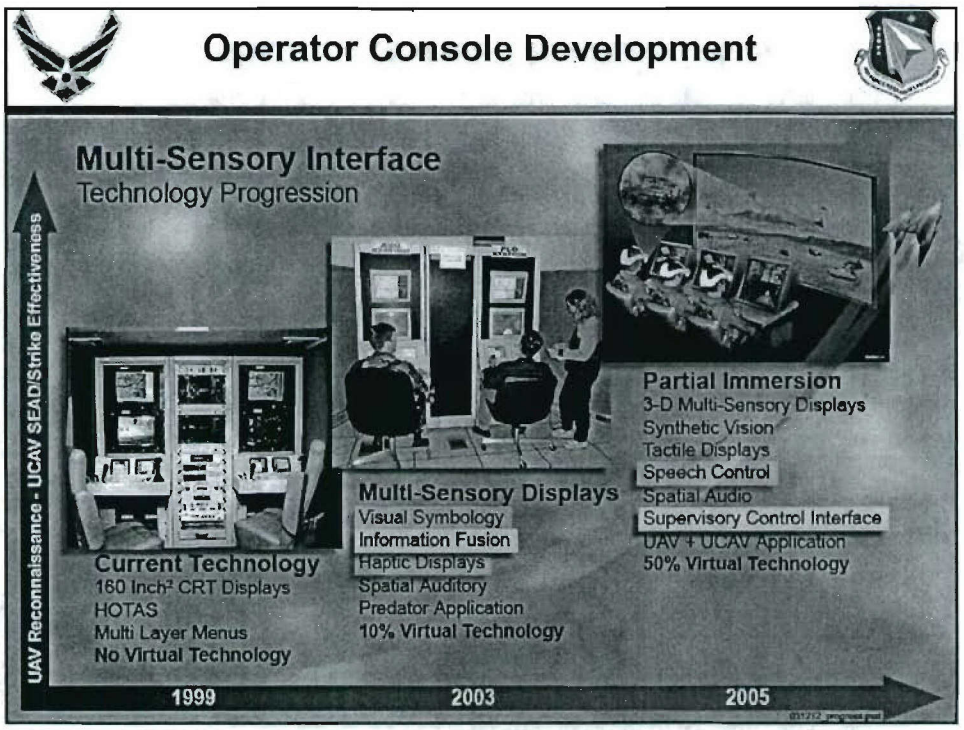
Split Screen Format Example



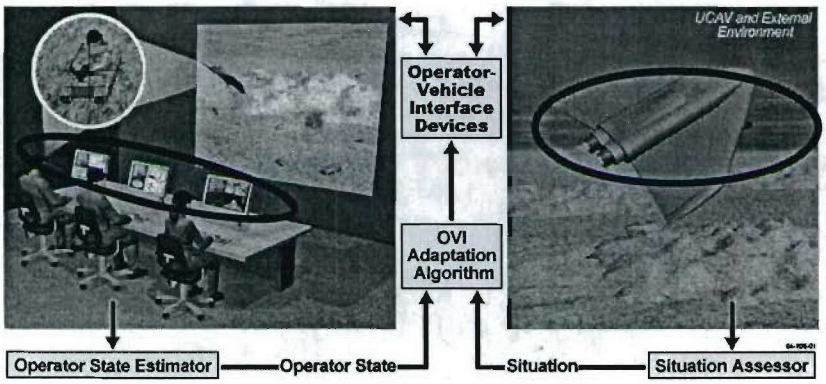
Mission Control Station Experimental Laboratory



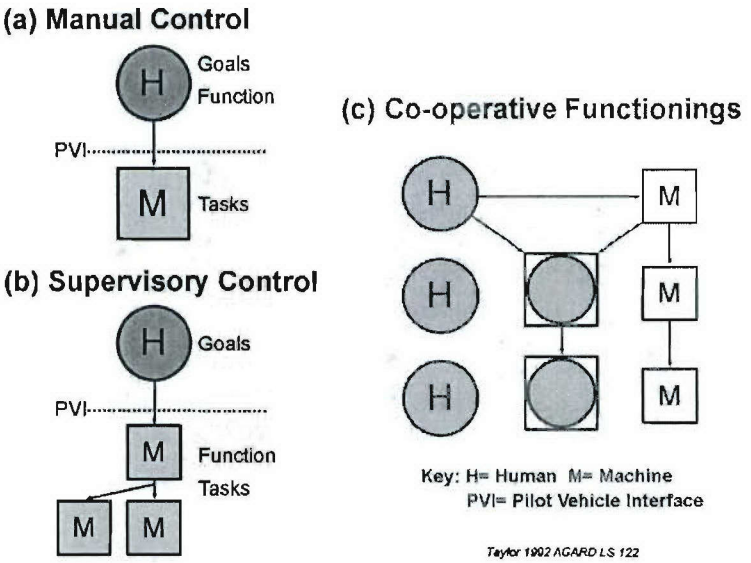
Operator Console Development



Operator-Vehicle System Diagram



Human-machine Control Architectures



Taylor 1992 AGARD LS 122

Automation Concerns

ACCIDENTS DIRECT FOCUS ON COCKPIT AUTOMATION
DAVID HUGHES/BOSTON and MICHAEL A. DORNHEIM/LOS ANGELES

DRAMATIC INCIDENTS HIGHLIGHT MODE PROBLEMS IN COCKPITS
MICHAEL A. DORNHEIM/LOS ANGELES

AIRBUS SEEKS TO KEEP PILOT, NEW TECHNOLOGY IN HARMONY
PIERRE SPARACO/TOULOUSE, FRANCE

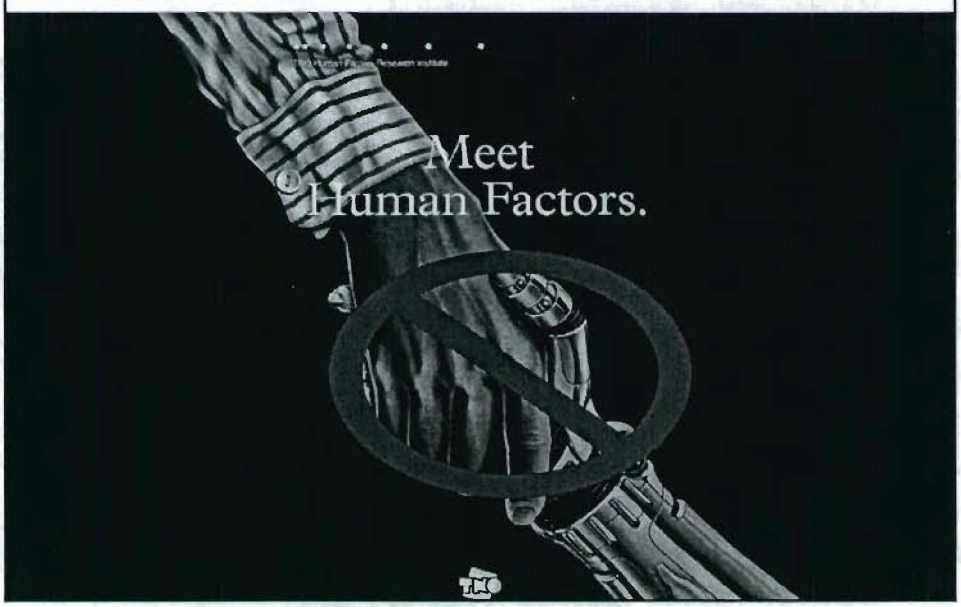
NTSB: MODE CONFUSION POSES SAFETY THREAT
EDWARD H. PHILLIPS/WASHINGTON

INCIDENTS REVEAL MODE CONFUSION
DAVID HUGHES/BOSTON

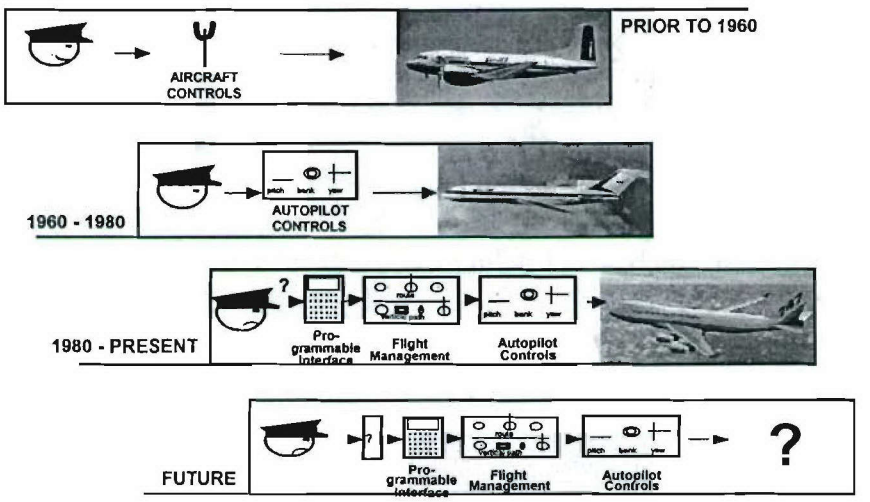
CERTIFICATION OFFICIALS GRAPPLE WITH FLIGHT DECK COMPLEXITY
WILLIAM B. SCOTT/COLORADO SPRINGS

STUDIES HIGHLIGHT AUTOMATION 'SURPRISES'
DAVID HUGHES/BOSTON

Human and Machine Co-operate

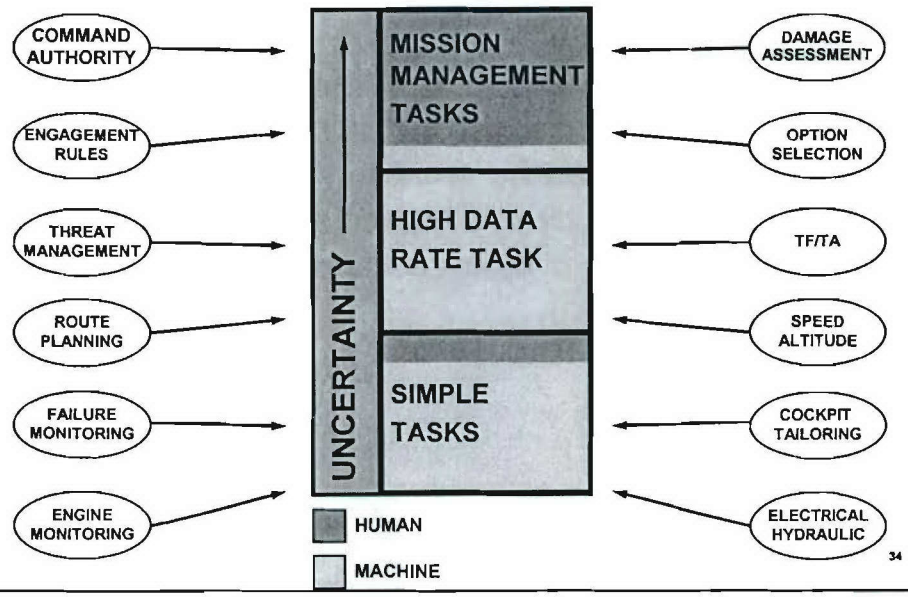


Increasing Automation



33

TASK PARTITIONING



34

Associate System

- Associate systems are computer-based aiding systems that are intended to operate as an **associate** to the human user. (Geddes, 1997, p.221)
- **A member without full status or privileges.**
  (Webster's New World dictionary 1968, p. 89)

Mixed Initiative -- ***both*** human and decision aid can take action.

Bounded Discretion -- the human is in charge.

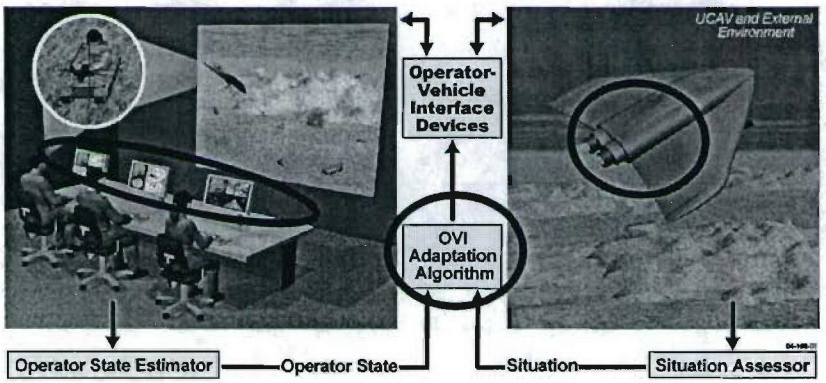
Domain Competency-- decision aid has broad competency, but may have less expertise than its human counterpart.

Adaptive Automation

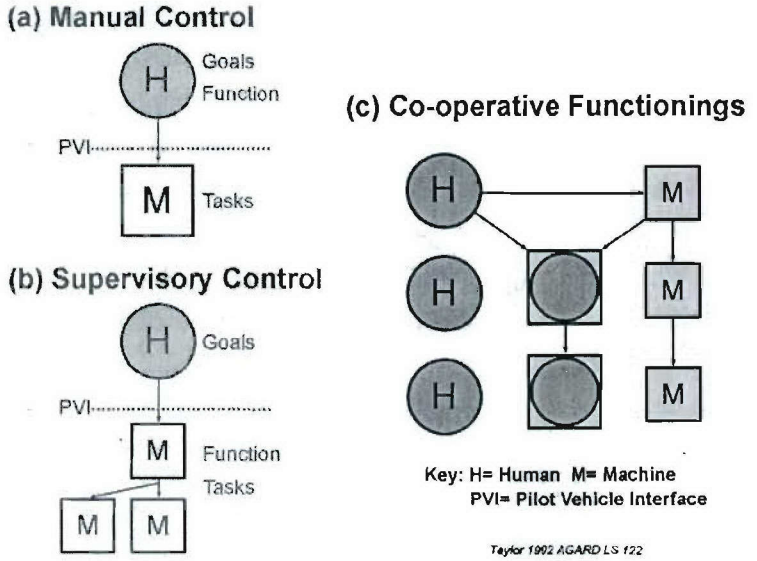
In adaptive automation, the **level or mode** of automation or the **number of systems** that are automated can be **modified in real-time**. Furthermore, **both** the human and the machine share control over changes and the state of automation.

Scerbo, p. 43 in *Automation and Human Performance*, 1996.

Operator-Vehicle System Diagram



Human-machine Control Architectures



Taylor 1992 AGARD LS 122

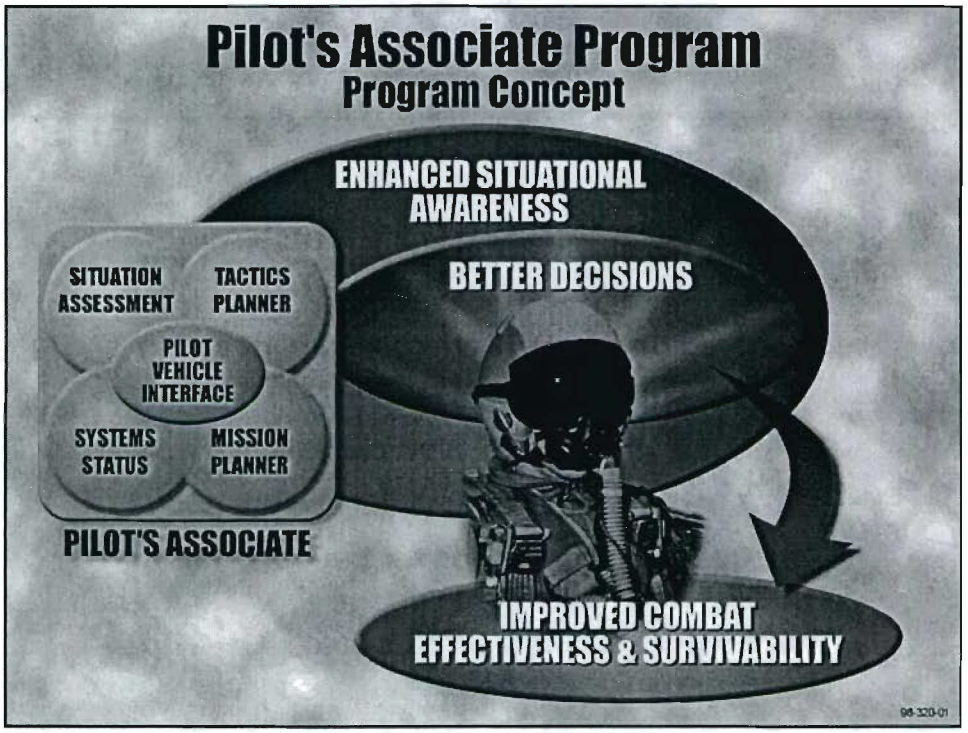
Level of Automation and Human/System Roles

Level of Automation	Human Role	System Role
1. None	Decide, Act	----------
2. Decision Support	Decide, Act	Suggest
3. Consensual AI	Concur	Decide, Act
4. Monitored AI	Veto	Decide, Act
5. Full Automation	---------	Decide, Act

Endsley, Automation and Situation Awareness, p. 174, 1996.

Three Phases of Trust Building

- Early Phase: Based upon the **predictability** of another's behaviors
- Intermediate Phase: Dependability -- **"Summary statistic** of an accumulation of behavioral evidence, which expresses the extent to which another person may be relied upon" (Muir, International Journal of Man-Machine Studies, 1987, 532.)
- Final Stage: **Faith** that a person will be dependable in the **future.**



Prime Directives for Associate Systems: Example--Three Laws of Robotics

- A robot *may not harm* a human being, or, through in action, allow a human being to come to harm.
- A robot *must obey the orders* given to it by a human being except where such orders would conflict with the first law.
- A robot *must protect its own existence* as long as such protection does not conflict with the first or second law.

Asimov,I. I, Robot, 1950

The Effort Required of the Pilot to Control the PA Must Be Less Than the Effort Saved by the PA.

- Plans may be:

  Approved or rejected explicitly

  Approved or rejected pre-mission

  Approved or rejected implicitly by pilot action

  Ignored, with predictable results
- The PA must operate in a predictable manner.
- All PA actions must be tailorable by the pilot.
- The PA is required to monitor the pilot, not the other way around.
- The PA must follow the pilot's lead.

RPA Rotorcraft Pilot's Associate

Focused Digital Battlefield Information

- Process Intel "real-time" from all available resources
- Gather Intel data to relay to higher echelons

Real-time Situational Assessment

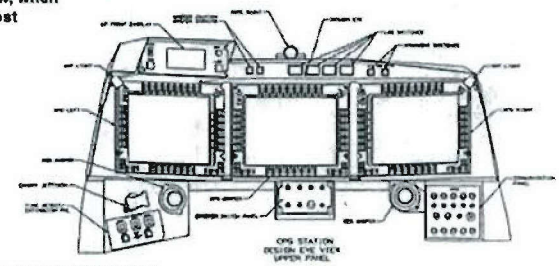
- Reasons on info to assess battlefield situation and aircraft/team members' conditions
- Infer the enemy's intent

Cockpit Information Management

- Provides pilot selectable task automation
- Monitor crew actions/reactions to predict information required for situation
- Present info to crew, when needed, in form most easily understood

Real-time Computer-Aided Decision Making

- Understands commander's intent; infers pilot's intent & plans accordingly
- Presents options for changing battlefield situations &: pilot makes dicisions
- Plans for Route, Recon, Attack, Com, Survivability, and Sensors



Sources: http://eustis-aatdac.army.mil/rpa/about/rpaov00.htm & http://eustis-aatdac.army.mil/rpa/vision/rpani32.htm

98-086-01/01R

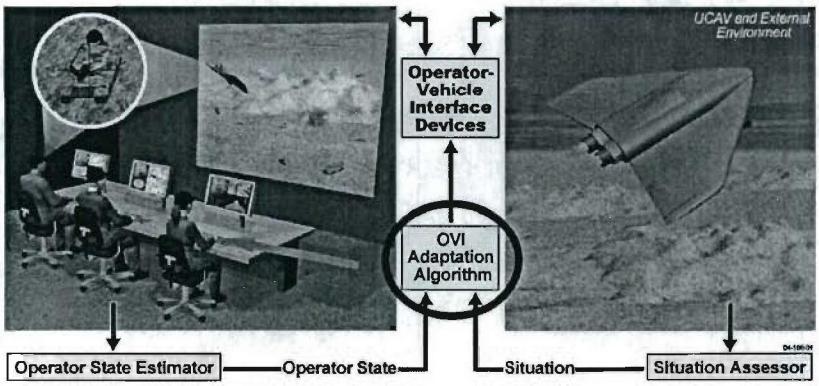
Rotorcraft Pilot's Associate: Real-time Computer-aided Decision Making

- **Understands Commander's Intent; Infers Pilots Intent and Plans Accordingly**
- Presents Options for Changing Battlefield Situations, and Pilot Makes Decisions
- Plans for Route, Recon, Attack, Com, Survivability, and Sensors

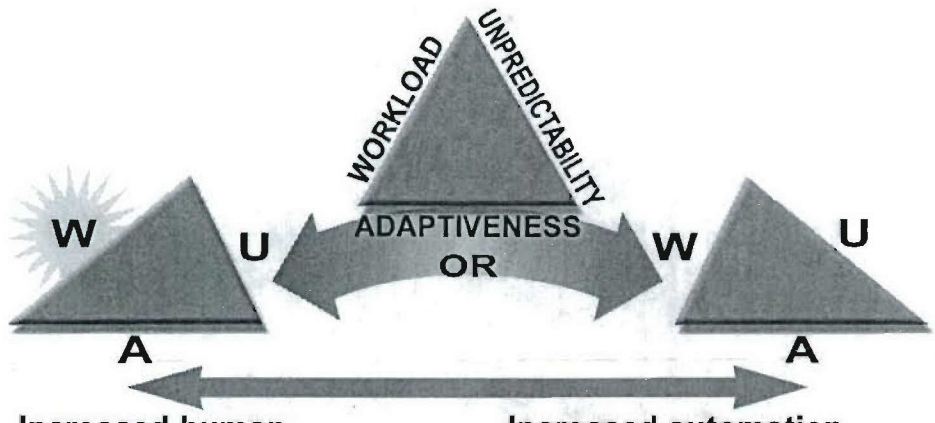
45

Longbow Apache

Operator-Vehicle System Diagram



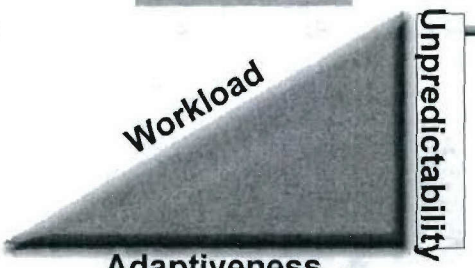
Workload, Unpredictability and Adaptiveness



Increased human management role yields increased human workload

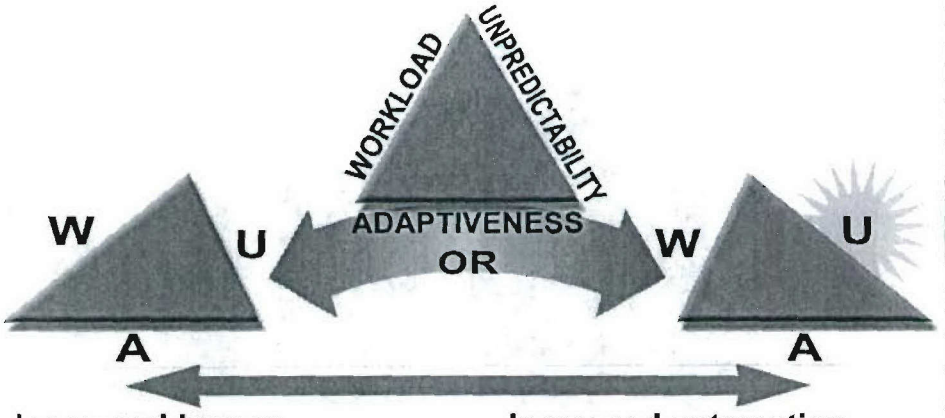
Increased automation management role yields increased unpredictability to human

Increased Workload



"I have to watch Robonaut closely to make sure the job is done properly."

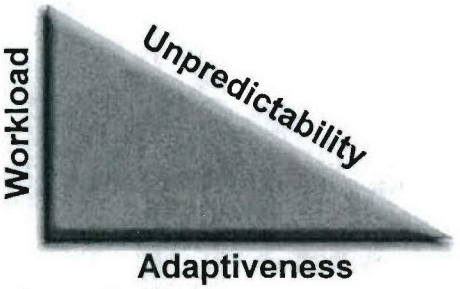
Workload, Unpredictability and Adaptiveness



Increased human management role yields increased human workload

Increased automation management role yields increased unpredictability to human

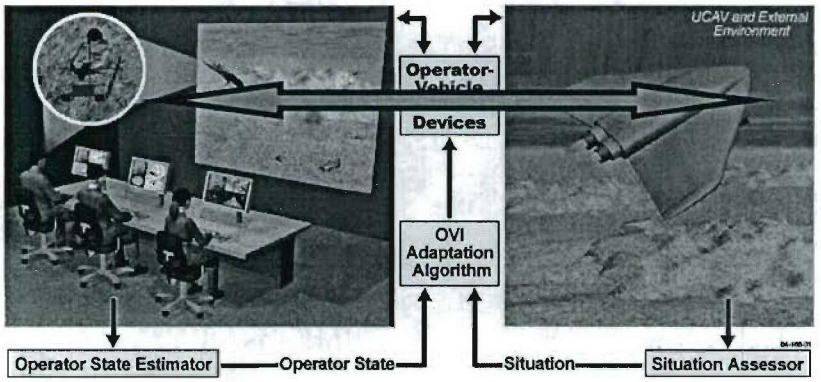
Increased Unpredictability



"What is PSA doing now?"

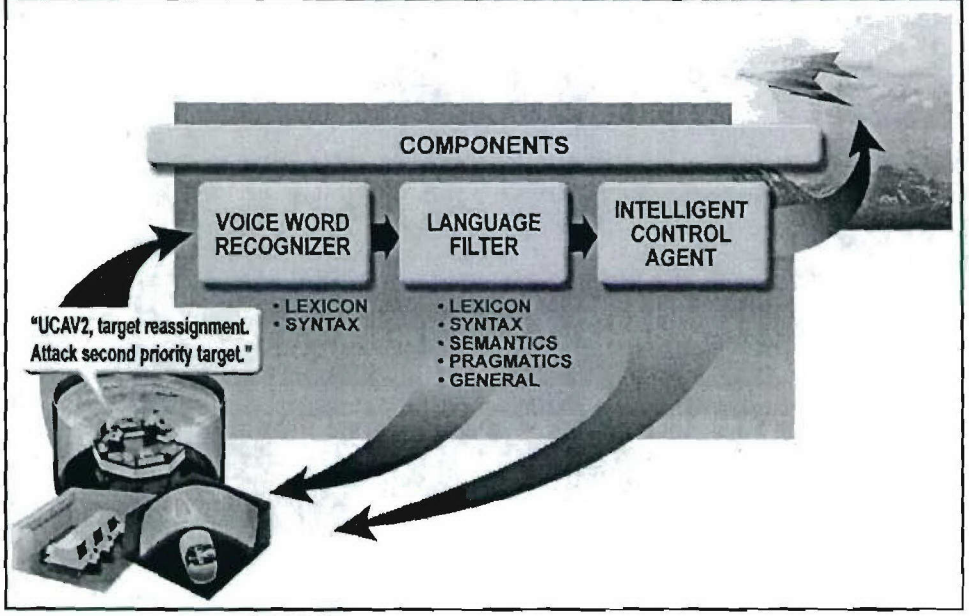
51

Operator-Vehicle System Diagram

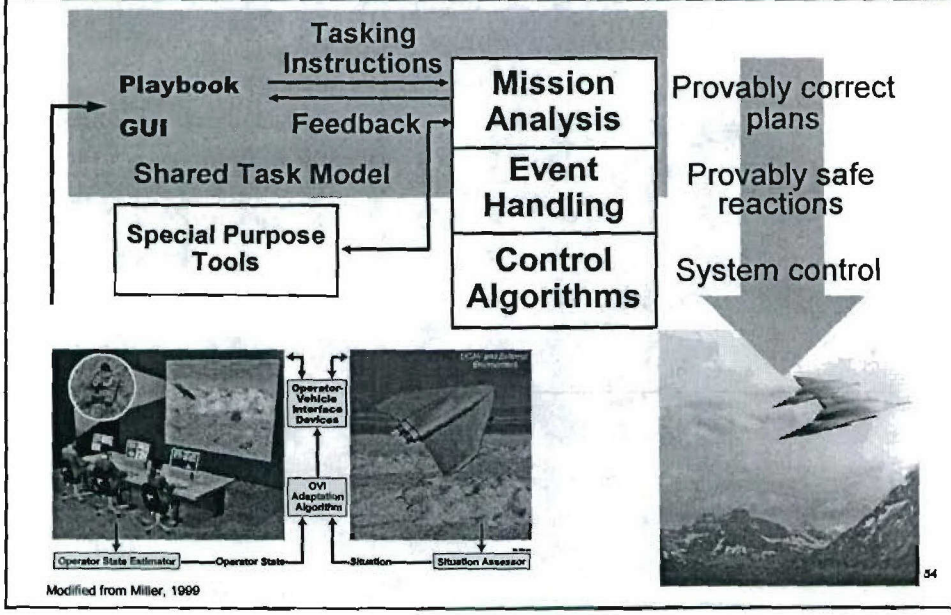


52

Higher Level Control



General Architecture for Tasking Interfaces



Modified from Miller, 1999

Plan Generated From GUI Playbook

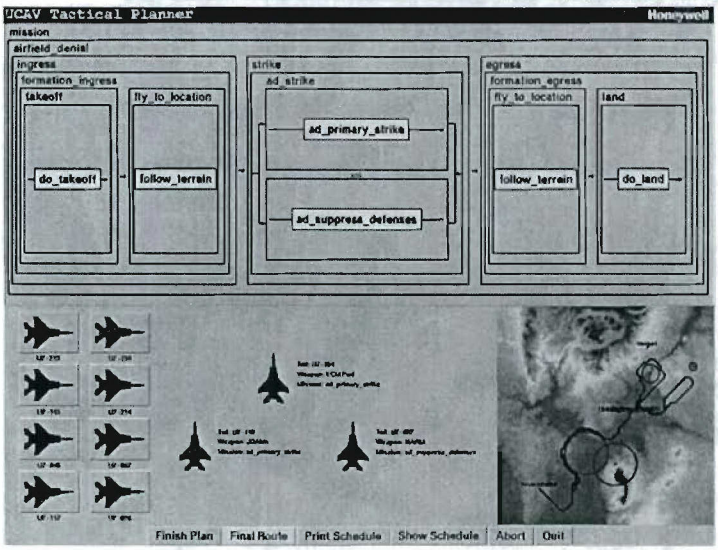
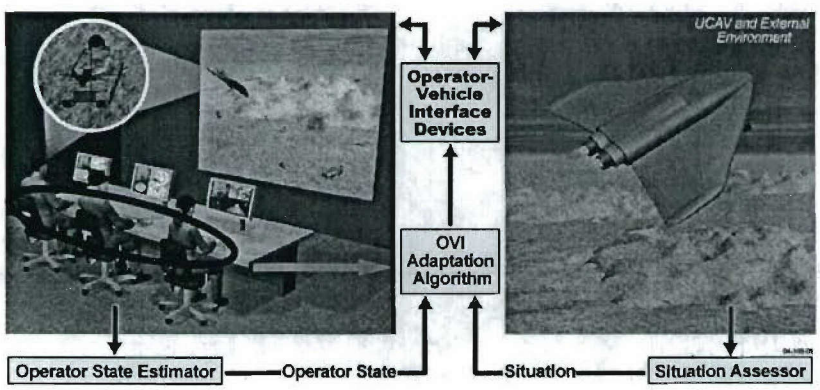


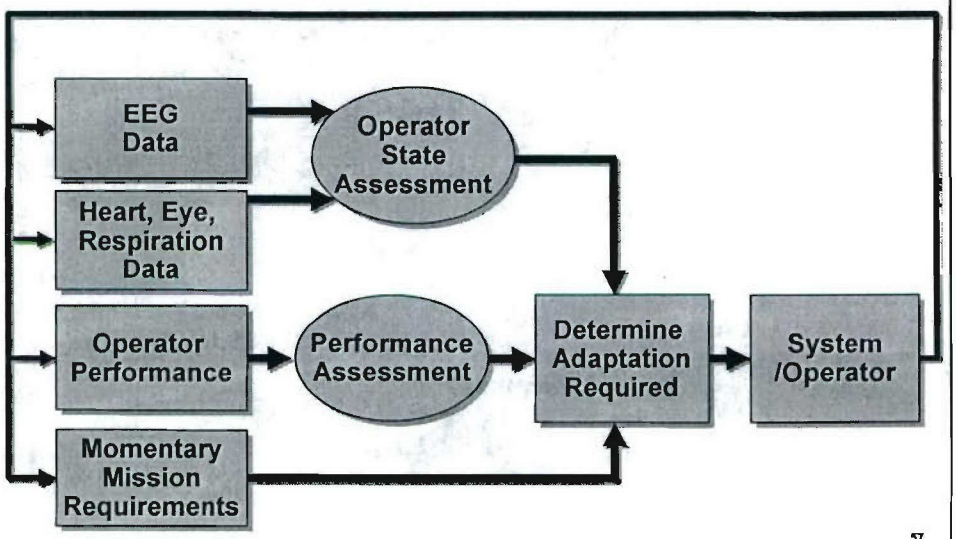
Figure 9. Finished plan returned by the MAC after User specification of the Ingress task.

Miller, Pelican and Goldman, 1999

Operator-Vehicle System Diagram

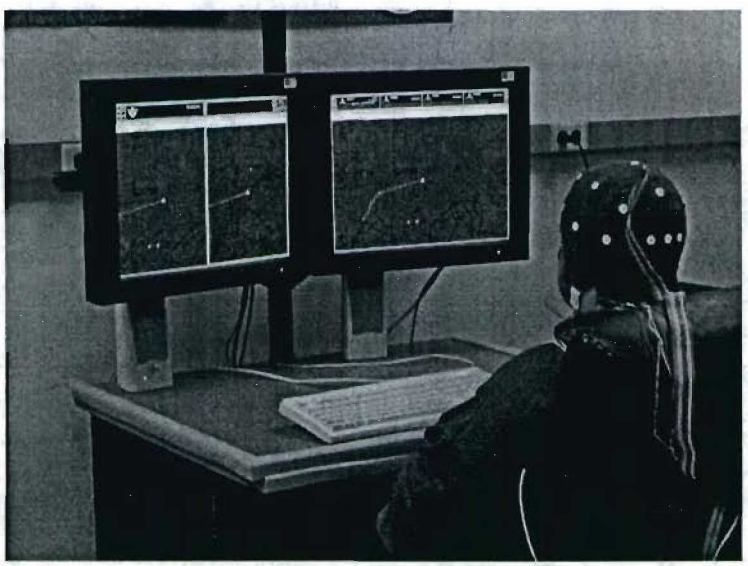


Adaptive Automation System Diagram



57

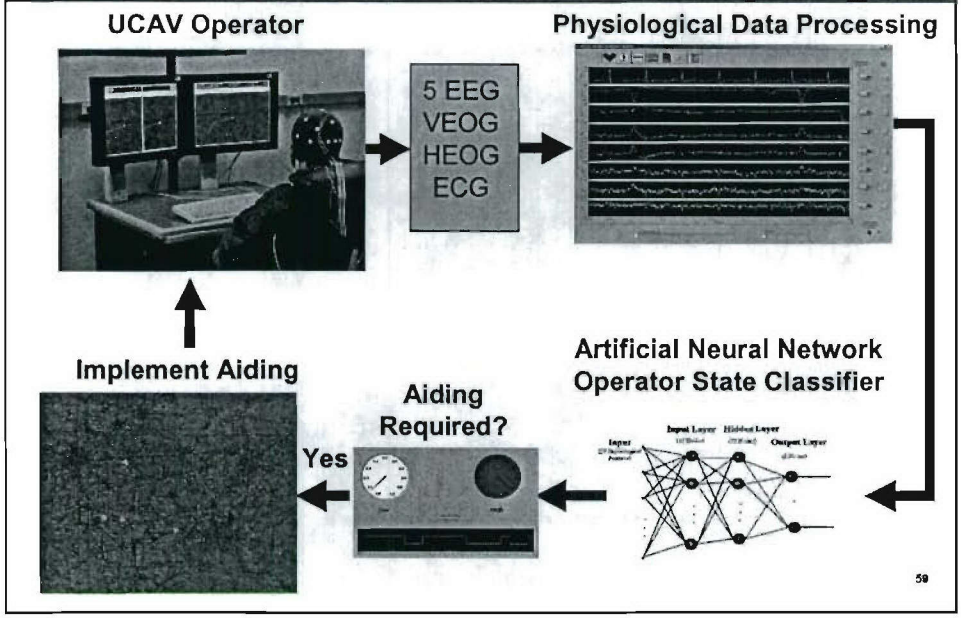
UCAV Adaptive Automation



58

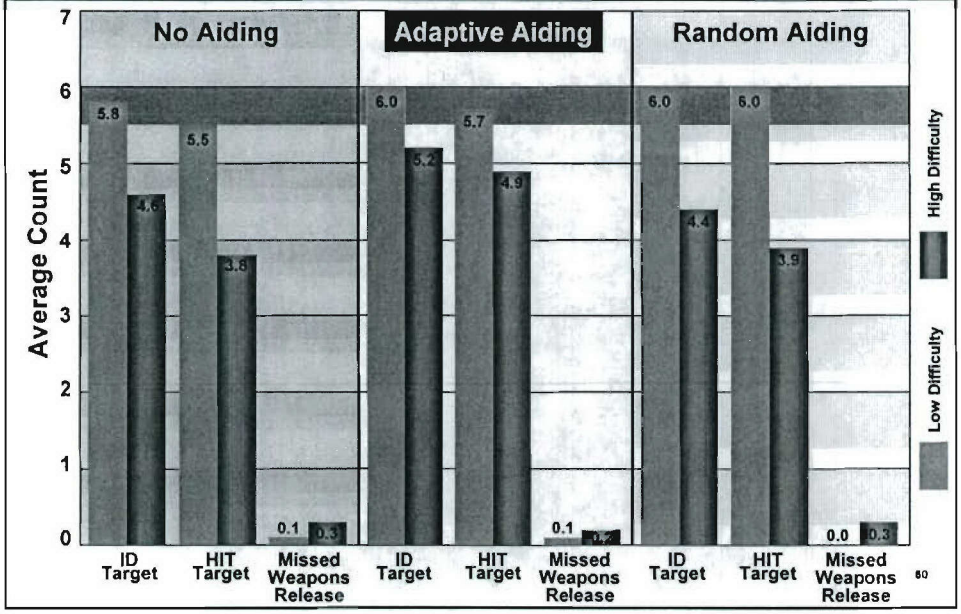
Current Research Program

Closed Loop Adaptive Aiding - OVI UCAV Simulator



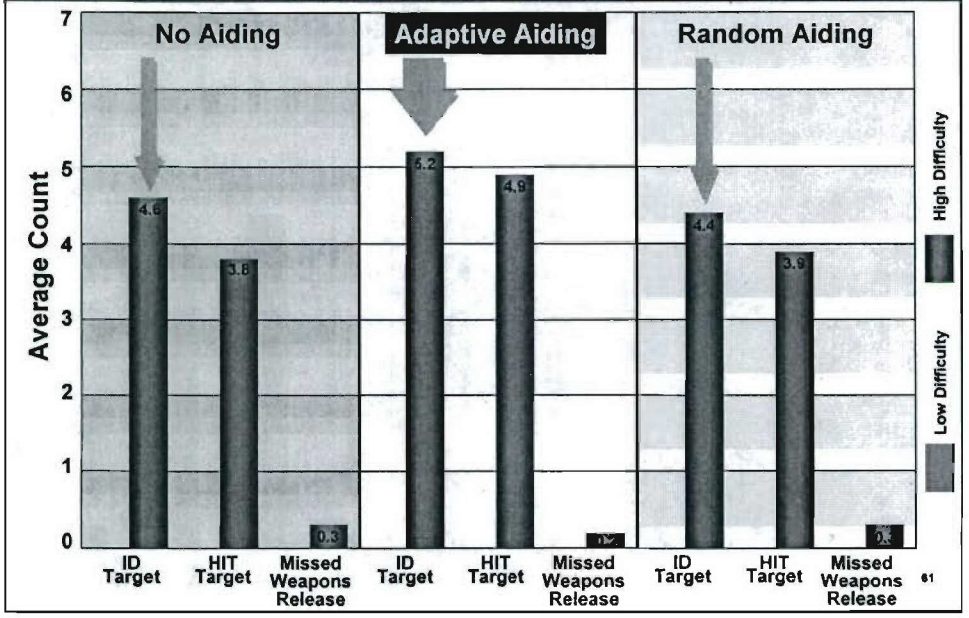
59

Performance Results



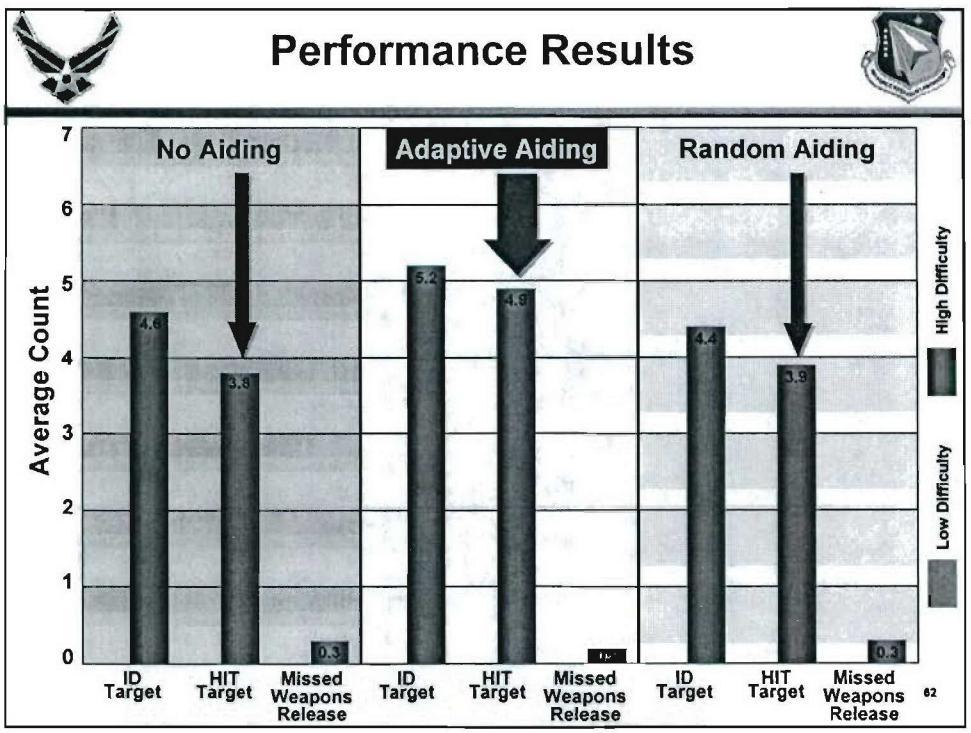
60

Performance Results



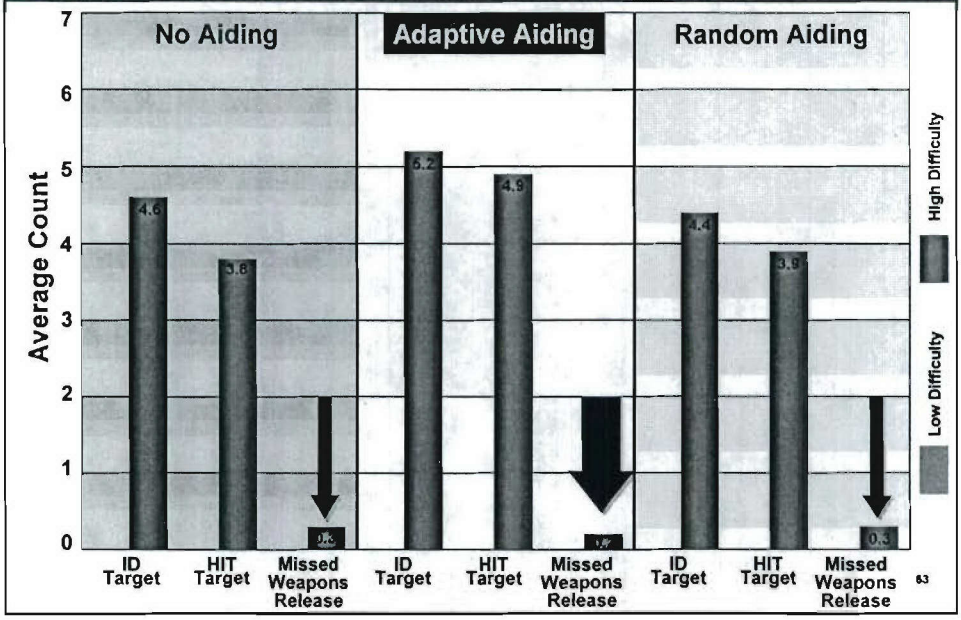
61

Performance Results



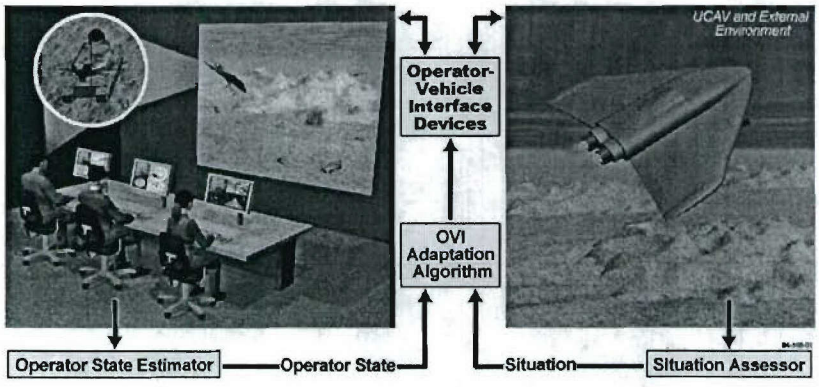
62

Performance Results



63

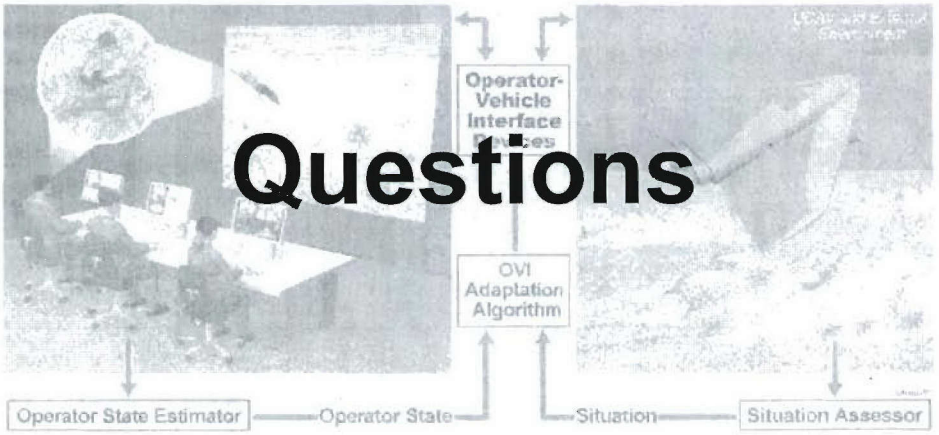
Operator-Vehicle System Diagram



64

Summary

- Affordability will result in a **high degree of automation** in the UMV operator's console.
- Control of the UMV will be defined more in terms of **mission management** than manual control.
- Changes on the battlefield will require a very **flexible automation architecture.**
- Successful **team building** between the operator and the automation will require **trust** between the two.
- The UMV operator/console system is a **key feature** in achieving future mission success.



Questions

- **Slide 1** Contains four pictures: **A)** Across the top of the slide are the Summary Panels, one for each of the UAVs. The summary panels give the operator a quick view of the status of each of the UAVs. **B)** shows the command window. Two very important features are the yellow and red boxes. They enable the operator to disconnect from the boom after refueling and breakaway if an emergency occurs. **C)** The Fuel System display shows the total quantity and individual fuel tank quantities for the selected UAV .**D)** The refueling status display contains three lights. The lights are blue for ready (RDY), green to show contact with the boom (AR), and yellow to show the boom disconnect (DISC). The total fuel quantity of each UAV is shown below these three lights.

- **Slide 2** shows The Out-the-Window display which was a virtual display depicting the positional information of the UAVs and tanker.

- **Slide 3** shows position information about the UAVs, tanker, commanded positions. It is the primary mechanism for commanding the UAVs during the air refueling process.

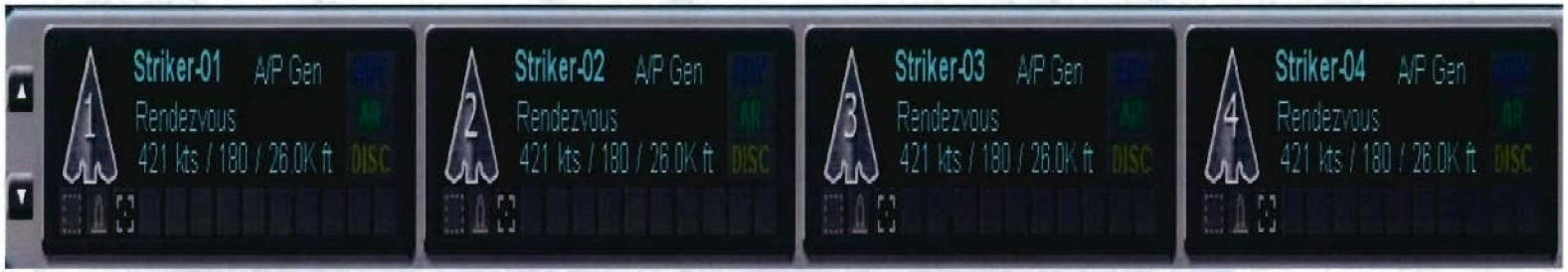
- **Slide 4** shows that once the UAVs were positioned at the observation positions, and the UAV operator received permission from the boom operator to move, the operator used the mouse to drag the selected first UAV, Striker 01, to the precontact position.

- **Slide 5** shows that the Striker 01 is now in the contact position.

- **Slide 6** shows that all of the Strikers have been refueled are now in the post refueling position.

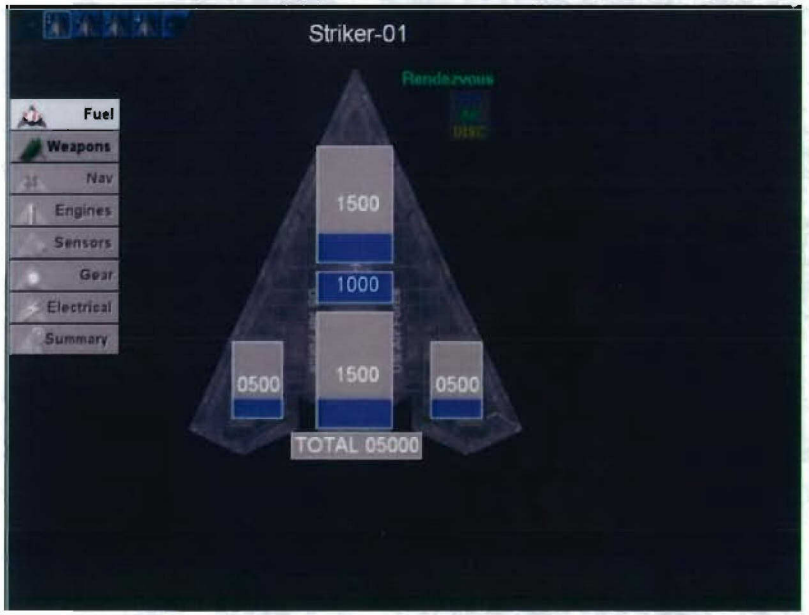
Slide 1 NOTE: Slides printed on both sides

A



B

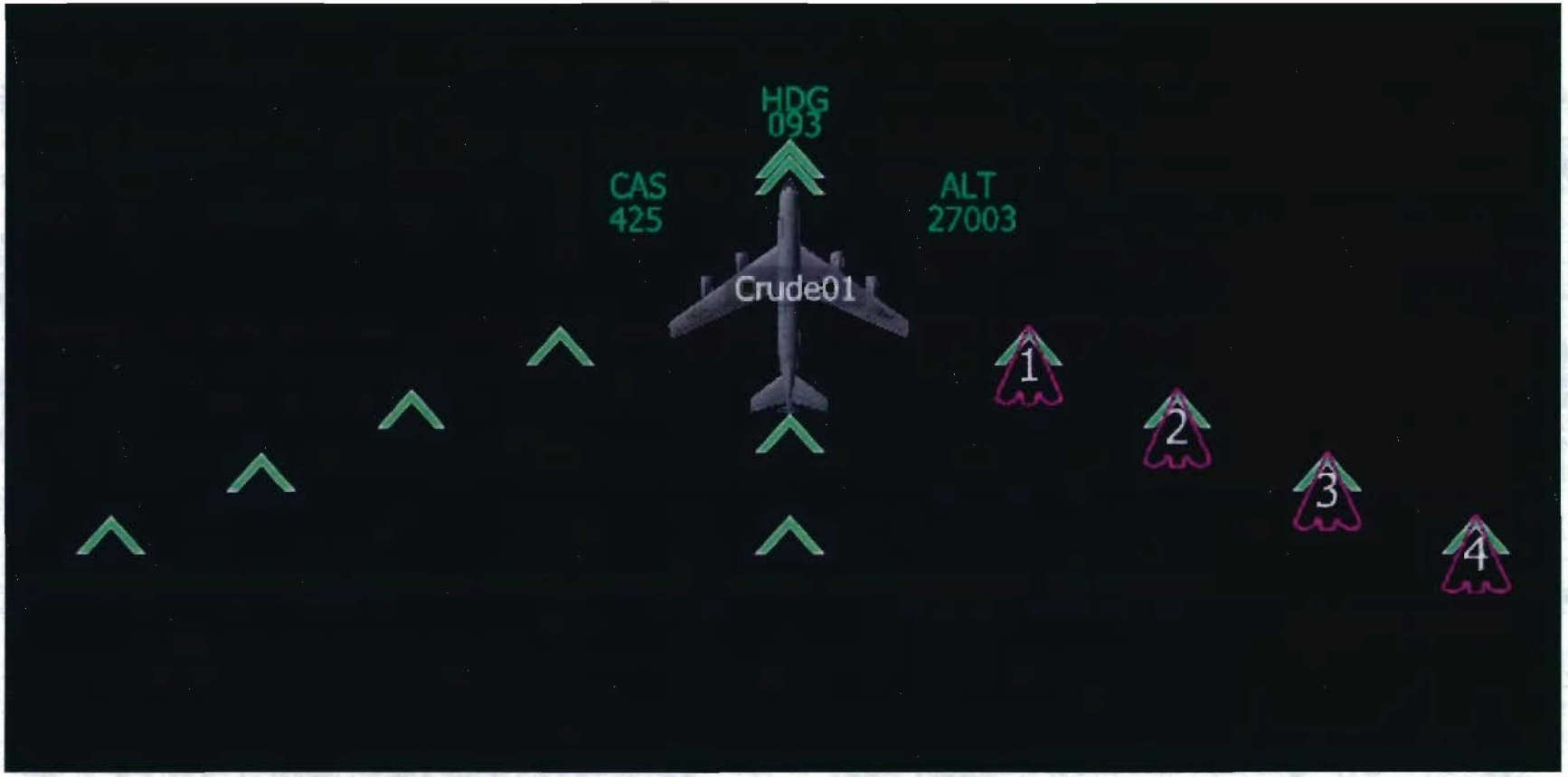
C



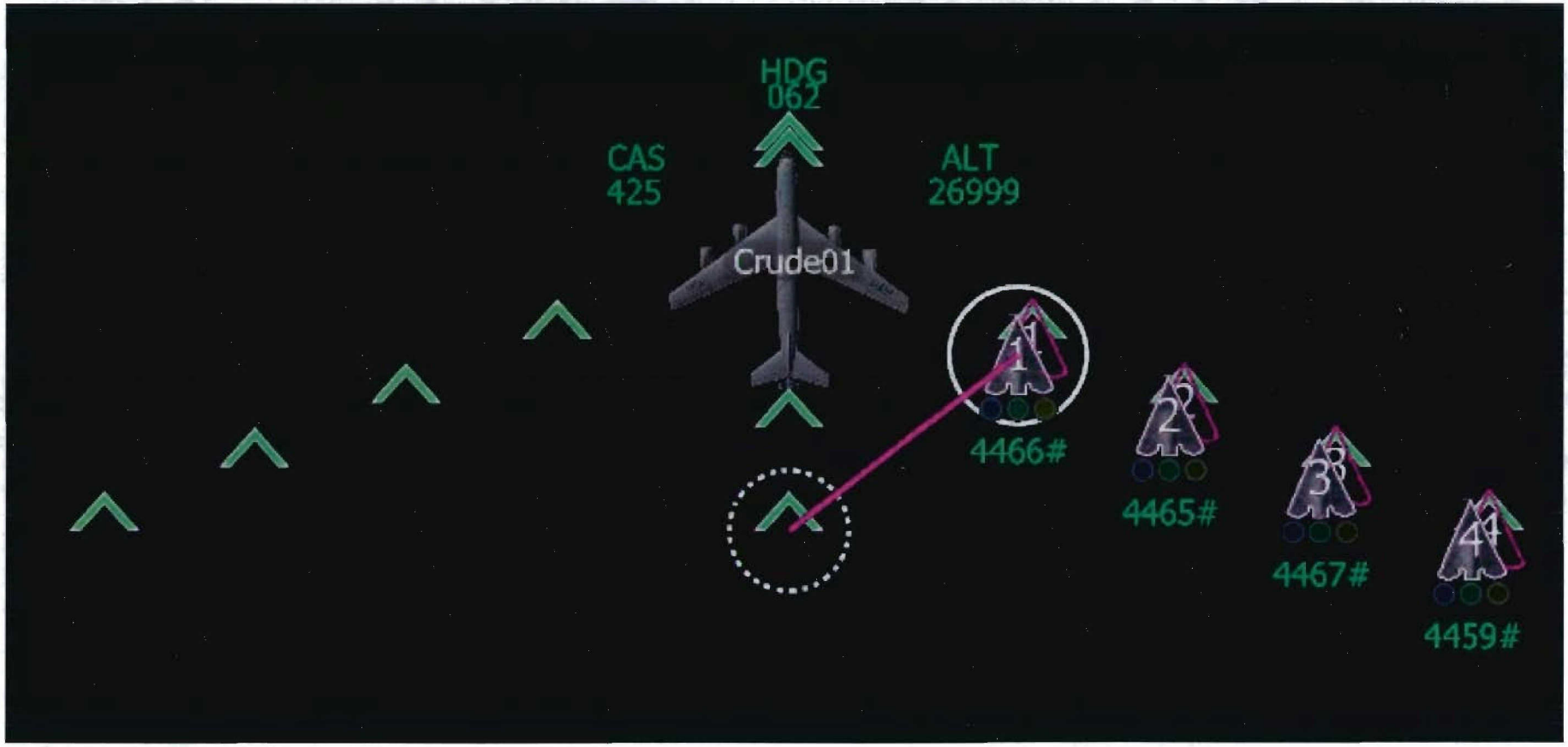
D

Slide 2

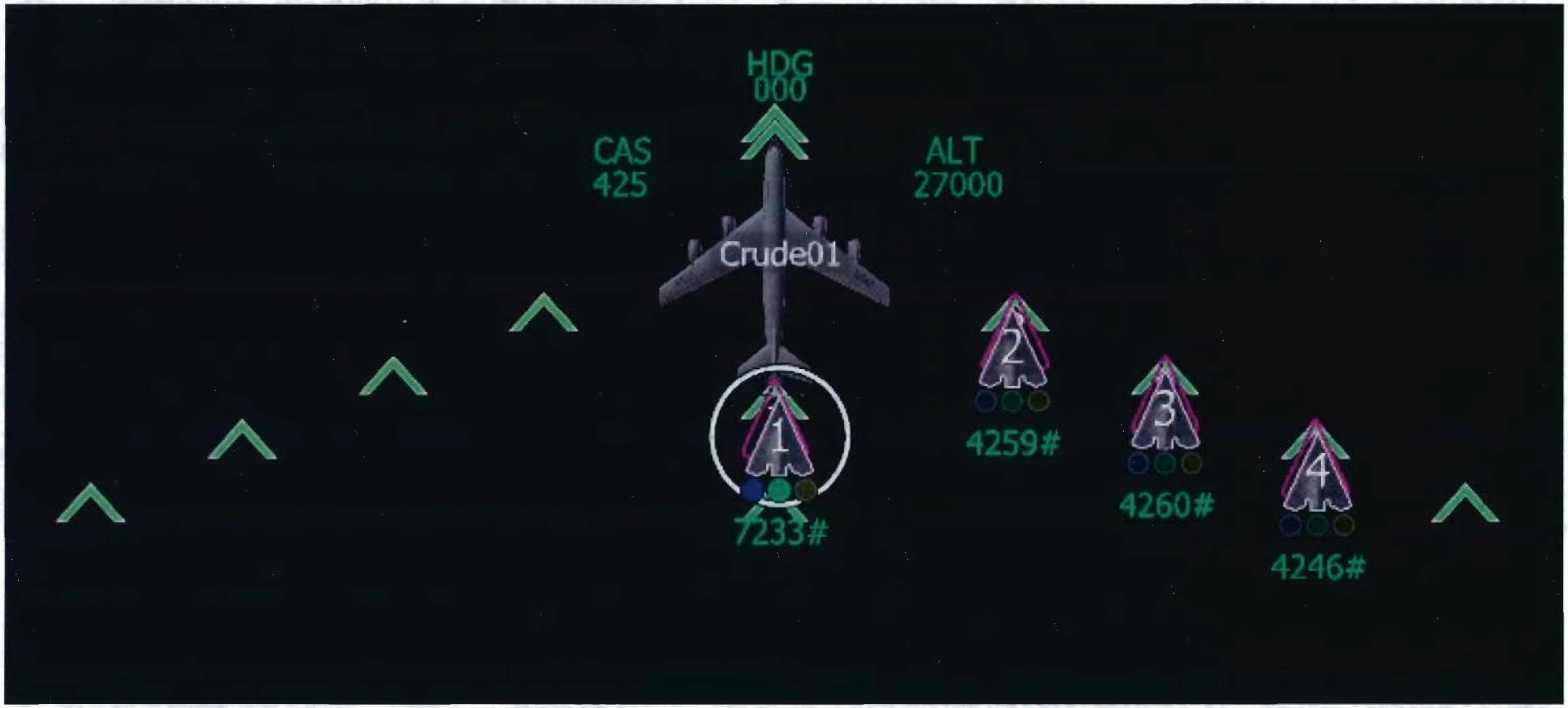
Slide 3



Slide 4



Slide 5



Slide 6